AFRL-AFOSR-JP-TR-2015-0002

Bio-inspired computation: clock-free, grid-free, scale-free, and symbol free

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11/06/2015
Final Report

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AF Office Of Scientific Research (AFOSR)/ IOA
Arlington, Virginia 22203
Air Force Materiel Command

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
11 JUN 2015	**Final**	**19-03-2012 to 18-09-2015**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Bio-inspired computation: clock-free, grid-free, scale-free, and symbol free	**FA2386-12-1-4050**
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER **61102F**
6. AUTHOR(S) **Janet Wiles**	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **The University of Queensland,1 Staff House Road,Brisbane,Australia,AU,4072**	8. PERFORMING ORGANIZATION REPORT NUMBER **N/A**
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) **AOARD, UNIT 45002, APO, AP, 96338-5002**	10. SPONSOR/MONITOR'S ACRONYM(S) **AFRL/AFOSR/IOA(AOARD)**
	11. SPONSOR/MONITOR'S REPORT NUMBER(S) **AOARD-124050**

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

The project developed a new fundamental component for bio-inspired computing, based on a new way of modelling spiking neurons, and applying them to a new type of long-range temporal prediction task. The new model neuron has been applied to event-based data from a new type of motion sensitive camera - the neuromorphic Dynamic Vision Sensor (DVS128). The model neuron incorporates temporal delays on both dendrites (inputs to neurons) and axons (outputs from neurons). Delays on axons have not previously been modeled in sensory-motor processing tasks, and their addition significantly simplifies asynchronous network development with spiking neurons, in particular reducing the computational complexity of algorithms for sparse data over dense sensory arrays. Effectively, the new model neuron treats each spike as a connection between temporal patterns extended in time in both its past and future.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**3**	

REPORT DOCUMENTATION PAGE

Form Approved

OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
06-11-2015	Final	19 Mar 2012 – 18 Sep 2015

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AOARD
UNIT 45002
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Bioinformation Systems, Computational Logic

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Brian Lutz, Lt Col, USAF
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Final Report for AOARD Grant #FA2386-12-1-4050 AOARD 124050

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18 September 2015

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Period of Performance: 03/19/2012 – 09/18/2015

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See the list of publications for full details.

Introduction: The objective of this project was to develop new forms of computation, free from clock-based synchrony, grid-based spatial structures, able to operate across multiple scales (scale-free) and able to infer symbolic information from sensory-motor streams that have no pre-determined symbols.

Experiment: Complete details of the methods are in the published papers listed below.
The DVS128 lens is frameless (pixel changes are sent asynchronously, which mimics the action of a biological retina, sending spikes only when the image changes, and only for pixels which register a change. The new sensor enables us to test spiking neural models with spike-like sensory data. This new data format requires changing the computational paradigm from conventional (clock-based and uniform-scale) computation to a much more robust and adaptive form (clock-free and scale-free).

Results and Discussion:
The network was tested on a high dimensional prediction task (16,384 pixels from DVS video data). Simulations compared the new prediction neurons to a conventional iterative paradigm on motion sequences: the new approach has much lower error within its prediction range.

List of Publications and Significant Collaborations that resulted from your AOARD supported project:
a) Peer-reviewed journals: none to date
b) Peer-reviewed conferences:

Gibson, T, Henderson, JA and Wiles, J. "Event-Based Visual Data Sets for Prediction Tasks in Spiking Neural Networks." Artificial Neural Networks and Machine Learning–ICANN 2014. Springer, 2014. pp 635-642.

Gibson, T, Henderson, JA and Wiles, J. "Predicting temporal sequences using an event-based

spiking neural network incorporating learnable delays." IEEE International Joint Conference on Neural Networks (IJCNN), 2014.

c) Non-peer-reviewed journals and conference proceedings:

Gibson, T, Henderson, JA and Wiles, J. "Finding Structure in Spikes" presented at NeuroEng, the 7th Australian Workshop on Computational Neuroscience, Adelaide (2014 Jan).

Henderson, JA, Gibson, T, and Wiles, J. "Deep Polynchrony networks" presented at NeuroEng, the 7th Australian Workshop on Computational Neuroscience, Adelaide (2014 Jan).

Gibson, T and Wiles, J "Predicting temporal sequences using an event-based spiking neural network incorporating learnable delays" at the University of Queensland Engineering Postgraduate Conference, Brisbane, Australia (2014 June).

d) Conference presentations without papers: none
e) Manuscripts submitted but not yet published:

Henderson, JA, Gibson T, and Wiles, J. "Spike Event Based Learning in Neural Networks." arXiv preprint arXiv:1502.05777, under review (submitted 2015).

Gibson T, and Wiles, J. "Thinking in light-cones: A novel metric for processing DVS event data using speed-based clustering", under review (submitted 2015).

f) Interactions with industry or with Air Force Research Laboratory scientists or significant collaborations that resulted from this work: None to date.

Attachments: Publications a), b) and c) listed above.